Appendix I

THE HONG KONG POLYTECHNIC UNIVERSITY
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Cost-benefit Analysis of the Green-Deck Development

(Final Report)

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Cost-Benefit Analysis of the Green Deck Development
Executive Summary

The Green Deck Development is a massive and ambitious project that intends to change the existing urban façade and living environment by constructing a multi-functional open space with a number of social facilities. This study uses cost-benefit analysis (CBA), which is a widely used tool to assist the decision making on investments, to evaluate whether the construction is beneficial to the society. The costs and benefits evaluated in the CBA process include direct and indirect, tangible and intangible items. For green infrastructure investments like the proposed Green Deck, benefits involved are mainly in the environmental and social aspects, such as air quality, public health etc. These environmental and social goods are usually not traded in the market. Therefore, by only evaluating the economic benefits, the total benefits of the investment would be underestimated as the non-marketed goods are neglected. Thus, especially for green infrastructure projects, carrying out a CBA is essential before the decision making process.

To identify the Green Deck associated costs and benefits, and to build the CBA framework, a literature review is conducted. This study mainly relies on secondary data since the Green Deck design is still at the preliminary stage. For the analysis, the discounting period lasts for over 50 years of the project lifetime starting from the construction stage, and the construction duration is assumed to be 5 years. The discount rate is set at 4% as suggested by the Hong Kong government.

The CBA resulted in a positive NPV, a B/C ratio of 1.3, and an IRR of 5.3%, showing that the Green Deck development is economically viable, and that the total benefits outweigh the total costs. The benefits accessed include air pollution reduction, carbon sequestration, visitor’s expenditure, temperature reduction etc. Social benefits consist of about 2/3 of the total benefits, which further confirms the positive effect that the Green Deck is able to brought into the society. Considering different scenarios, the NPV of the Green Deck development ranges from HK$ 1.5 billion to HK$ 2.9 billion, which shows that in the less ideal scenario, the NPV is still found to be positive (HK$1.5 billion).

This study gives a preliminary and brief estimate on the costs and benefits of the Green Deck development, which can serve as a reference for future decision making. Based on the CBA results, it is concluded that the Green Deck development is a worthwhile and acceptable investment that can generate positive effects environmentally, socially, and economically.

1. INTRODUCTION

1.1 Background

Hong Kong is being recognized as one of the densest cities in the world. Local citizens are facing the challenges of living in an overcrowded urban environment with limited open space, intensified urban heat island effect, and air and noise pollutions. Many literatures have reported the significance of urban green space to the well-being of a society. It is seen as an essential element in developing a sustainable city by improving resilience to extreme weather events and climate change, enhancing biodiversity and ecosystem services, and improving public health and well-being, as well as increasing social cohesion (CIWEM, 2010). The Hong Kong Polytechnic University's (PolyU) proposed Green Deck is an ambitious project that intends to change this existing urban façade and living environment by constructing a multi-functional open space for the neighborhood. The proposed Green Deck will be located above the Hung Hom Cross Harbor Tunnel (CHT) and its Toll Plaza area, and adjacent to the Hung Hom MTR station podium (west), with an area of 43,000 m^2 (Figure 1).

Nevertheless, urban green infrastructures are previously underrated and they are regarded as having less contribution to economic growth than transportation, energy and sanitation infrastructures. This misconception is partly due to market failure since the benefits of urban green space are mainly in the environmental and social aspects, such as air quality, public health, and carbon reduction, which are external effects that are not being considered in the market mechanism (Konijnendijk, 2013, Rouwendal and van der Straaten, 2008). If these intangible benefits are underestimated or being ignored in the decision making process, the true value of urban green space could not be revealed, and sustainability and efficient resource allocation might not be able to achieve.

1.2 Objectives

Therefore, the objectives of this study are:

- To identify and quantify the tangible and intangible costs and benefits of the Green Deck development, so that a clearer understanding of the costs and benefits brought by urban green space could be provided to the decision

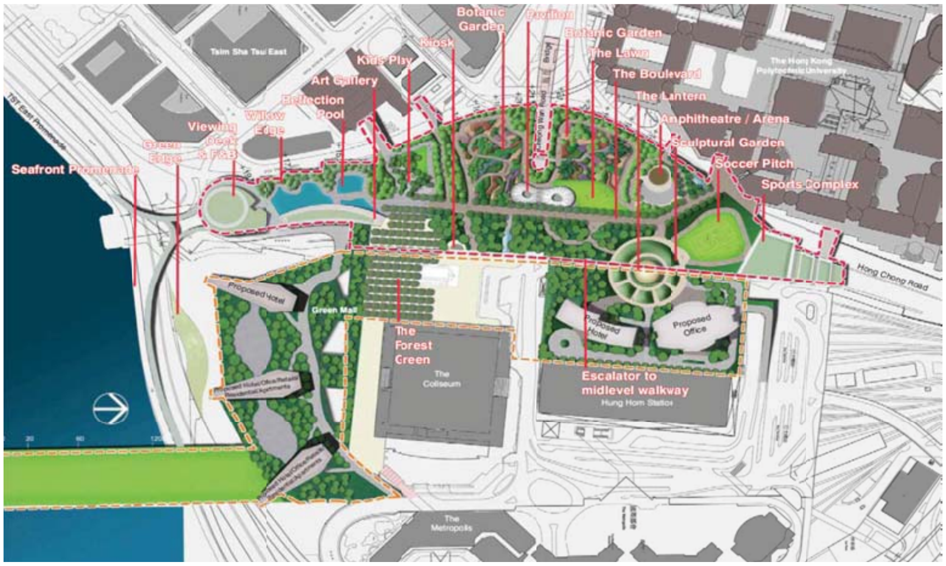


Figure 1 Landscape Master Plan of Green Deck Development

makers with scientific basis;

- To determine whether the total benefits of the Green Deck development outweigh its total costs;
- To develop an Excel analyzing tool to conduct cost and benefit analysis for infrastructure investments.

1.4 Methodology

Cost-benefit analysis (CBA) is a tool to assist the decision making on investment, provided that resources are scarce (CEEU, 2012). For private investments, the main goal is profit maximization. Thus, decision making is according to private costs and private benefits, which are reflected in the market mechanism (CEEU, 2012). However, for the public sector like the government, investment decision should not be solely based on private costs and benefits, but the society as a whole (CEEU, 2012). CBA could serve this purpose as it is a 'process of identifying, measuring and comparing the social benefits and costs of an investment project or program' (Campbell and Brown, 2003). The costs and benefits evaluated in the CBA process include both direct and indirect, tangible and intangible items. By comparing all the costs and benefits involved in the investment project, one can evaluate if the total benefit exceeds the total cost, or vice versa. Therefore, especially for green infrastructure projects, carrying out a holistic CBA is essential in the decision-making process.

One major concept involved in CBA calculation is the opportunity cost as the primary purpose of CBA is to evaluate the net benefits of the investment, and how it fares against an alternative or base case (Marsden Jacob Associates, 2005), which is also called the 'with' and 'without' project scenarios (Campbell and Brown, 2003). As resources are limited, resources consumed for the proposed project should be justified against its use for other purposes. As a result, this opportunity cost denotes the 'cost' in the CBA because carrying out Project A needs to forgive the opportunity of carrying out Project B (Campbell and Brown, 2003). Therefore, the purpose of CBA is to compare how the society would be different 'with' and 'without' the investment project.

In general, four steps are involved in conducting CBA – first, to identify the costs and benefits associated with the project; second, to estimate the market values of the costs and benefits; third, apply the discounting factor and analyze the options with decision rules; and finally to conduct sensitivity analysis to examine how the result will differ under various scenarios (CEEU, 2012). The CBA process is illustrated in Figure 1.

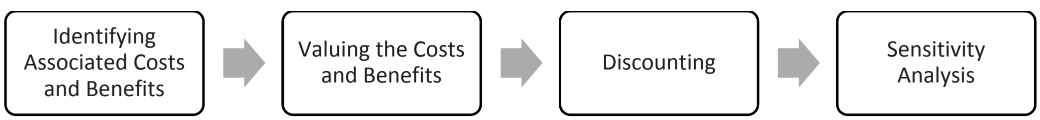


Figure 1 CBA Process

Source: CEEU (2012)

1.4 Expected Outcome

The associated economic, social and environmental costs and benefits from the construction to operation of the Green Deck would be identified and quantified as much as possible under the limited data and resources available. The CBA framework will be constructed, and the holistic CBA would provide decision rules such as net present value (NVP), benefit-cost (B/C) ratio and internal rate of return (IRR) as a reference for determining whether the Green Deck development is an acceptable investment in terms of the interest of the society.

2. A REVIEW OF LITERATURE

Literature review is carried out to identify the associated costs and benefits of both construction and operation stage in order to construct the Green Deck CBA framework.

A) Construction Stage

i) Costs

1) Initial Investment and Design and Consultation Cost

Construction or initial investment cost is usually the largest costs involved. It is regarded as an explicit cost, which means that there is an explicit monetary payment, or a direct value that can be inferred to (National Center for Environmental Economics Office of Policy, 2014). The Design and consultation expenses are also included as part of the project cost. For most of the infrastructure projects, it is usually found to be less than 5% of the total investment cost (Lee and Jung, 2015; European Commission, 2015).

2) Cost of Temporary Traffic Congestion

There is no doubt that construction work on the road would lead to traffic congestion. According to a Hong Kong government report, road works are deemed as one of the major reasons for traffic congestion in Hong Kong (Transport Advisory Committee, 2014). In Nigeria, construction work could cause traffic delay for 2 minutes in average (Atomode, 2013). On the other hand, more delay time is found in the US. McCann et al. (1999) reported a 10-15 minutes traffic delay due to road works in New Jersey and Salt Lake City.

This traffic time delay takes a toll on the society. Congestion on the road has a significant cost to the commuters and other drivers, in which time cost lost is the major concern (Metropolitan Planning Council, 2008). The time lost in traffic congestion of the Chicago metropolitan region could lead to an extra cost of US$5.1 billion for the commuters (Metropolitan Planning Council, 2008).

3) Construction Carbon Emission

Yan et al. (2010) have identified the major sources of carbon emission during building construction in Hong Kong. They included 1) manufacturing and transporting building materials; 2) energy consumption of on-site construction equipment; 3) energy used for processing resources; and 4) emission of fossil fuel combustion of construction waste disposal. Among these sources, the author found that the production of building materials take up the highest percentage, about 82-87% of the total emission. Similar result is observed in a residential complex construction of Guangdong Province, China. The production of building materials is found to be the main source of carbon emission during construction, which accounted for 2/3 of the total emission (Hong et al., 2015).

B) Operation Stage

i) Costs

1) Operation and Maintenance Cost

Operation and maintenance (O&M) cost is regarded as variable cost as it changes with the volume or intensity of the output (Central Expenditure Evaluation Unit, 2012). The O&M cost of parks can vary greatly, depending on the park use and design (The Trust for Public Land, 2008). For example, the O&M cost of urban parks in the City of Minneapolis can range from US$$229,000 to $884,000 per acre (The Trust for Public Land, 2008).

2) Operation Carbon Emission

During the operation of the Green Deck, electricity use would generate carbon emission. Kong et al. (2014) conducted a study on urban turfs in Hong Kong and Shenzhen, and found that the electricity use in managing the turfs could emit 73.6kg to 178 kg carbon equivalents per year. In the US, Villalba et al. (2013) investigated the carbon footprint of the Yosemite National Park. In terms of total emission, electricity use consists of 17%, with 7,812 tonnes of carbon emission in year 2011.

ii) Benefits

1) Revenue

Revenues such as rental fee or entry fee to the recreation providers should be included in benefit valuation of CBA (Briceno and Schundler, 2015). Nadel (2005) conducted a CBA for the Golden Gate National Recreation Area, in which the fees, ticket sales, and any gross revenues are included in the calculation.

2) Visitor's Expenditure

Briceno and Schundler (2015) did an economic analysis of recreation land use in the Washington State, US. The research showed that the annual trip related visitor's expenditure for the public outdoor recreation land uses is about US$10.7 billion, which as a result could generate great economic activity in the country. According to the report, the expenditures included gas and oil, food and beverage, grocery, retail etc., and excluding the purchase of equipment. Among them, gas and oil contributed the greatest (23%), followed by food and beverage (17%) (Briceno and Schundler, 2015).

3) Air pollution reduction

Air pollution would adversely affect human health, especially to the cardiovascular and respiratory systems (McPherson, 1992; Harnik and Welle, 2009). The ability of trees and shrubs to remove air pollutants is proven by various studies. Through dry deposition, which is a process of absorbing air pollutants into the plant tissue with stomata, plants could reduce concentration of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), and particulate matters (PM) through their surface (Harnik and Welle, 2009; Jim and Chen, 2008; McPherson et al., 2002). However, the dry deposition rate depends on the plant species, roughness of leaf surface, and atmospheric conditions (Jim and Chen, 2008). Therefore, the air pollutant removal rate of plants varies from place to place.

According to Tan and Sia (2005), a green roof in Singapore can absorb 6% of atmospheric PM and 37% of SO_2 per year. Similar study has also been conducted in Hong Kong. Peng and Jim (2015) looked at the intensive green roofs in Hong Kong, and concluded that the annual reduction for SO_2, NO_2, and PM is 31kg/ha, 12.4kg/ha, and 195kg/ha respectively. On the other hand, the air pollutant reduction level in Guangzhou is found lower than that in Hong Kong. Trees on recreational land use in Guangzhou could reduce SO_2 by 23.83kg/ha, NO_2 by 24.29kg/ha, while PM by 88.79kg/ha per annum (Jim and Chen, 2008).

4) Carbon Sequestration

Apart from removal of air pollutants, urban park can also act as a carbon sink. McPherson et al. (2002) suggested that urban trees in Sacramento, California can remove some 304,000 tonnes of atmospheric CO_2 a year, with a value of US$3.3 million. In Oakland, California, one hectare of trees can sequestrate 11 tonnes of CO_2 each year (Nowak, 1993), where similar result is also found in Chicago (16.7 tonnes/ha/year) (Nowak, 1994). Although plants are able to absorb CO_2, the sequestration capacity differs with species since it counts on the photosynthetic and respiration rates, as well as the weather and environmental conditions (Chen and Jim, 2008; Peng and Jim, 2015). Peng and Jim (2015) reported a different carbon sequestration rate of trees in Shenzhen compare with that in the US. The authors studied 6 typical types of urban green space in Shenzhen city, and found the average annual carbon sequestration rate to be 25.7 tonnes/ha.

5) Noise Pollution Reduction

Noise exposure not only adversely affect human health, but also the economy as a whole. Studies concluded that when a person is constantly exposed to noise, negative health impact including higher risk of heart attack, hypertension, sleep disturbance, and even poorer reading performance in children can arise (Istamto et al., 2014; Swinburn et al. 2015). Economically, Brons et al. (2003) found that noise affecting school buildings, medical premises and residential areas could have a negative effect on human capital stock, which indirectly takes a toll on the economy. With the Green Deck, Tang (2014) suggested that it is able to reduce traffic noise level at the PolyU campus by 3dBA. The noise reduction would benefit the society as study in the US proved that a reduction of 5-dB L_{DN} in noise level could reduce the number of hypertension cases by 1.4% and coronary heart disease cases by 1.8% (Swinburn et al. 2015). Moreover, the cost of traffic noise pollution to the society can be measured by the Willingness To Pay (WTP) method. Studies in Europe found that the WTP for an excess dBA ranges from 15-20 euro per person (Howarth et al., 2001; Nijland et al., 2003), but this value would be affected by household income, gender, education level etc. (Istamto et al., 2014).

6) Surface Runoff Reduction

Another common indirect benefit of urban park is the reduction of surface runoff. Peak flow and runoff volume can be slowed down and reduced as vegetation intercepts rainfall, while soil absorbs water (Sherer, 2006; Harnik & Welle, 2009; Roehr and Kong, 2010; Vijayaraghavan et al., 2012). Study found that a tree can reduce 73 gallon of surface runoff each year (Aston, 1979), and this runoff reduction service provided by the plants is economically beneficial to the society. In Philadelphia, the total annual saving due to runoff reduction by urban parks is amounted to US$5,948,613 (Harnik and Welle, 2009). The rate of runoff reduction, however, depends on the soil depth, growing medium, and plant species (Roehr and Kong, 2010). Berardi et al. (2014) concluded after reviewing a number of researches that green roof could reduce surface runoff by 25-50%. On the other hand, a higher runoff reduction rate is reported in Speak et al. (2012). The authors conducted a study on the intensive green roofs in Manchester, UK, and 65.7% runoff reduction rate is achieved on average.

7) Temperature Reduction (Energy Saved and Emission Avoided)

Vegetation is proven to lower the temperature and alleviate the Urban Heat Island (UHI) effect, which in turn reduces energy consumption and greenhouse gas emission. The UHI effect is due to the high density of the built environment and the anthropogenic heat in the urban area (Chen and Wong, 2006). The high temperature would increase energy use for cooling and raise the electricity demand, as well as emitting more greenhouse gas to the environment through fossil fuel combustion during the energy production process (Chen and Wong, 2006; Zhang et al., 2014). To ease the UHI problem, urban plants could play a role as they can reduce air temperature through evapotranspiration, where the latent heat of vaporization is being absorbed in the atmosphere (Zhang et al., 2014). To understand the temperature reduction potential of urban greenery in the urban areas, Peng and Jim (2013) investigated the effect of intensive green roof in Hong Kong, and concluded that the green roof can lower temperature by 1.2◦C in the pedestrian level. Other studies on the cooling effect of urban parks in Asia showed a different result and have a range of temperature reduction from 0.2-2.2◦C (Chen and Wong, 2006; Ca et al., 1998).

Studies carried out in the US showed that with every 1◦C change in the ambient temperature, a 4% change in energy consumption from cooling could be found (Milward and Sabir, 2011; Jensen et al., 2003; McPherson et al., 1997). Similar pattern is found in Hong Kong. Fung et al. (2006) did an empirical study on the relationship between energy use in domestic, commercial, and industrial sectors and the ambient temperature change. Results indicated that with 1◦C temperature change, the electricity demand will change by 4.5% on average.

8) Health and Well-being

More and more studies confirm the positive effect of the presence of park on human health. Psychologically, it is suggested that human beings tend to get pleasure from trees through a sense of meaning and connection (McPherson et al., 2002), thus, people living near green area rated themselves as having better mental health, and with fewer complaints on health (Sherer, 2006). Physically, with access to park, studies found that people will exercise more (Sherer, 2006; Kahn et al., 2002). According to Kaczynski and Henderson (2007), if there is a park or walking trail nearby, 55% of the people would increase the exercise frequency. With extra physical activity, evidence showed that health would be improved. Sælensminde (2004) reported a 1% reduction in short-term absence from work with extra physical activity, while Cavill et al. (2008) found a 50% and 40-50% reduction in risk of getting coronary heart disease and colon cancer respectively for more physically active people. This increase in exercise due to the presence of urban parks is found to be beneficial to the society by saving cost for medication, the medical cost tends to be lower for people with more physical activity than that of their counterparts.

In the US, study shows that if 10% of adults started a regular walking exercise, US$5.6 billion could be saved in a year (Wang et al., 2005). Pratt et al. (2000) compared the medical cost difference between physically active and inactive person in the US. Physical active people in general pay US$280 less annually, which is similar with the finding of Harnik and Welle (2009) (US$250 per year). In Hong Kong, according to a survey conducted in 2001, the average monthly medical cost for physically active person is HK$596, while for those inactive is HK$748, with HK$152 difference (Louie and Hui, 2001).

9) Travel Time Reduction

Hung (2015) conducted a research on modeling the change in pedestrian flow at PolyU if the Green Deck was built. The study focuses on the footbridge connecting the Hung Hom Station and the PolyU campus, which has seen congestion problems during morning and evening peak hours. With the Green Deck, the pedestrian flow rate during the morning peak hour is reduced from 220 ped/min to 59-70 ped/min, while the flow rate during the evening peak house is reduced from 260 ped/min to 149-176 ped/min (Hung, 2015). Decreasing the flow rate can increase walking speed (Lam et al., 2000), thus saving time cost in travelling.

10) Property (Hedonic) Value

Various studies confirmed that with all else being equal, people are willing to pay more for a house that is close to the park, and this phenomenon is known as the 'hedonic value' (Harnik and Welle, 2009; Rouwendal and van der Straaten, 2008). In other words, this benefit can be interpreted as the value of 'aesthetics' (Bianchini and Hewage, 2012). With the park nearby, people's willingness to pay for the better environment is revealed in the willingness to pay for a higher rental price. Thus, the increase in property value is considered as one of the benefits that could be brought by the urban green space (Bianchini and Hewage, 2012). Bianchini and Hewage (2012) reported that with trees or greenery nearby, property values could increase by 15-25% in general. However, a lower value is found by Luttik (2000). The author looked at a small neighborhood and concluded that with a view of open space, the house price would increase by 6-12%. Nevertheless, this increase in property value is found to decrease with distance away from the park. Studies suggested that this effect can be measured up to 2,000 feet from the green space, with the greatest value found within first

500 feet (Harnik and Welle, 2009; The Trust for Public Land, 2010; Jim and Chen, 2010). Other researches also reported similar findings. Correll et al. (1978) observed a US$4.2 decrease in property value for every foot away from the green area, and More et al. (1988) indicated that the value of an apartment at 20 feet from the park could be US$2,675 higher than a same one that is 200 feet away.

3. THE CBA FRAMEWORK

This study analyzes the construction and operation stages of the Green Deck development, and both tangible and intangible costs and benefits are evaluated. In economic evaluation, costs and benefits are usually classified as 'private' and 'social'. According to the Intergovernmetal Panel on Climate Change (IPCC) working group report, private costs/benefits are those elements that would have influence on the individual decision makers, such as land and labor costs, fuel costs, and equipment cost etc. (Halsnæs et al., 2007). In other words, private costs and benefits are borne or enjoyed by the owner or decision maker itself only. On the contrary, social costs and benefits, which can also be called as externalities, are the costs and benefits that would impact the other individuals, and which is not being taken into consideration by the individuals who cause them (Halsnæs et al., 2007). In the Green Deck case, assumed that the government is the investor. All the direct costs and benefits such as construction costs, O&M costs, and revenues would be considered as 'private'. Other costs and benefits that are shared by the parties or individuals other than the government would be regarded as 'social'. Based on this classification, the Green Deck CBA framework is presented in Figure 2 and Figure 3.

In Figure 3, it is noted that for both private and social benefit, there are 'property (hedonic) value'. The private hedonic benefit means the net increase in rent of the: 1) potential retail stores on the Green Deck mid-level (assumed 50% of the area as retail), 2) the potential restaurant on the viewing deck (assumed 50% of the area as restaurant), 3) the potential new office building near the Green Deck, 4) the two potential new apartments near the Green Deck, and 5) the two potential new hotels near the Green Deck. Since these properties are not yet being built, the benefit of rental increase would be captured by the investor only, which in this case, it is assumed to be the government. Thus, these hedonic benefits are distinguished as 'private'. On the other hand, the social hedonic benefit refers to the net rental increase of the existing properties in the surrounding area near the Green Deck, which would be enjoyed by the individuals other than the government. Hence, the hedonic benefits of the nearby properties are considered as 'social'.

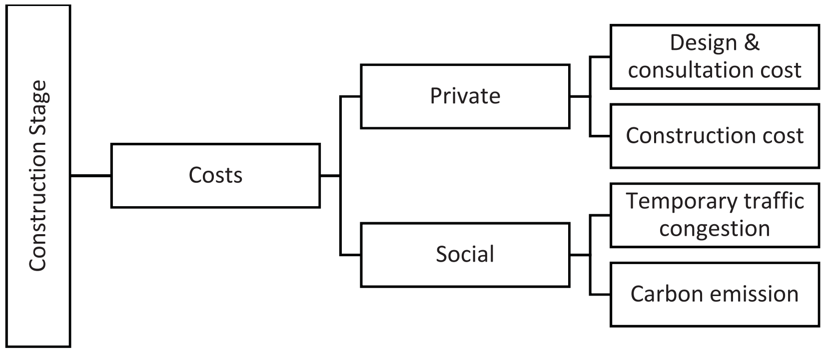


Figure 2 Construction stage framework

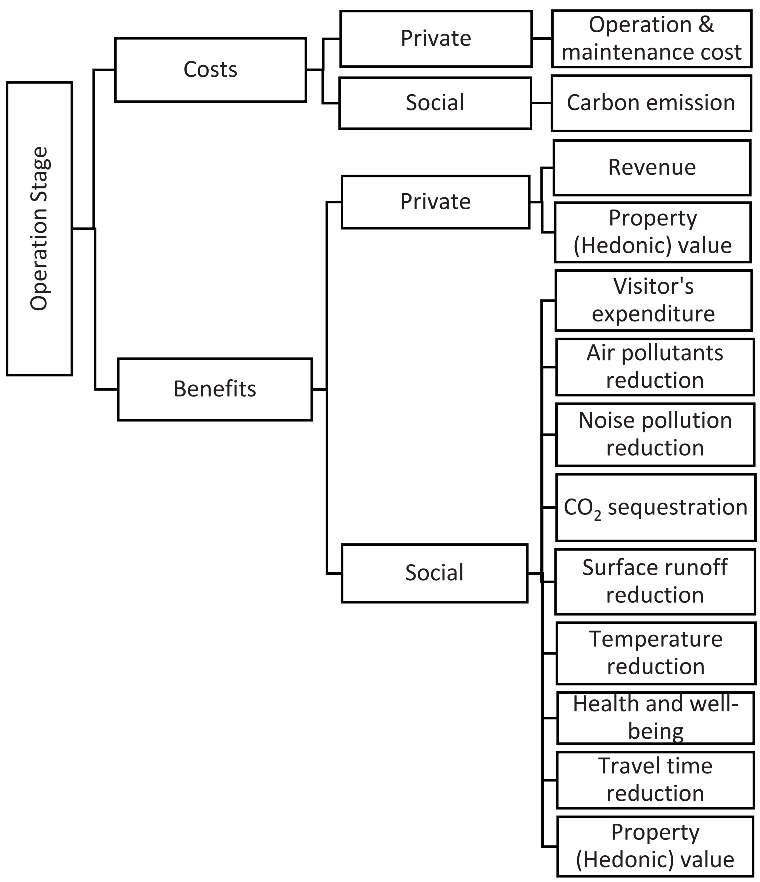


Figure 3 Operation stage framework

4. VALUATION METHODOLOGY & DATA SOURCE

In this section, the valuation method of the costs and benefits will be explained. The method of benefit transfer is used as the Green Deck design is still at the preliminary stage. Benefit transfer is 'the use of estimated nonmarket values of environmental quality changes from one study in the evaluation of a different policy that is of interest to the analyst' (USEPA, 2010). In choosing the relevant data, priority is given to local researches to minimize inaccuracy. Study results from other countries are used only if no local relevant data is available. To further increase the reliability of the CBA, the dollar values adopted from the US will be adjusted to Hong Kong dollar by using the Purchasing Power Parity (PPP) exchange rate published by the World Bank (US$1 = HK$5.69) (The World Bank, 2015) as the price level and the household income at the US are different from Hong Kong. The detailed calculation is demonstrated in the excel spreadsheets, which is provided separately. Figure 4 shows the layout of the spreadsheets, in which the private and social costs and benefits are calculated separately, and finally added together to compute the total discounted costs and benefits.

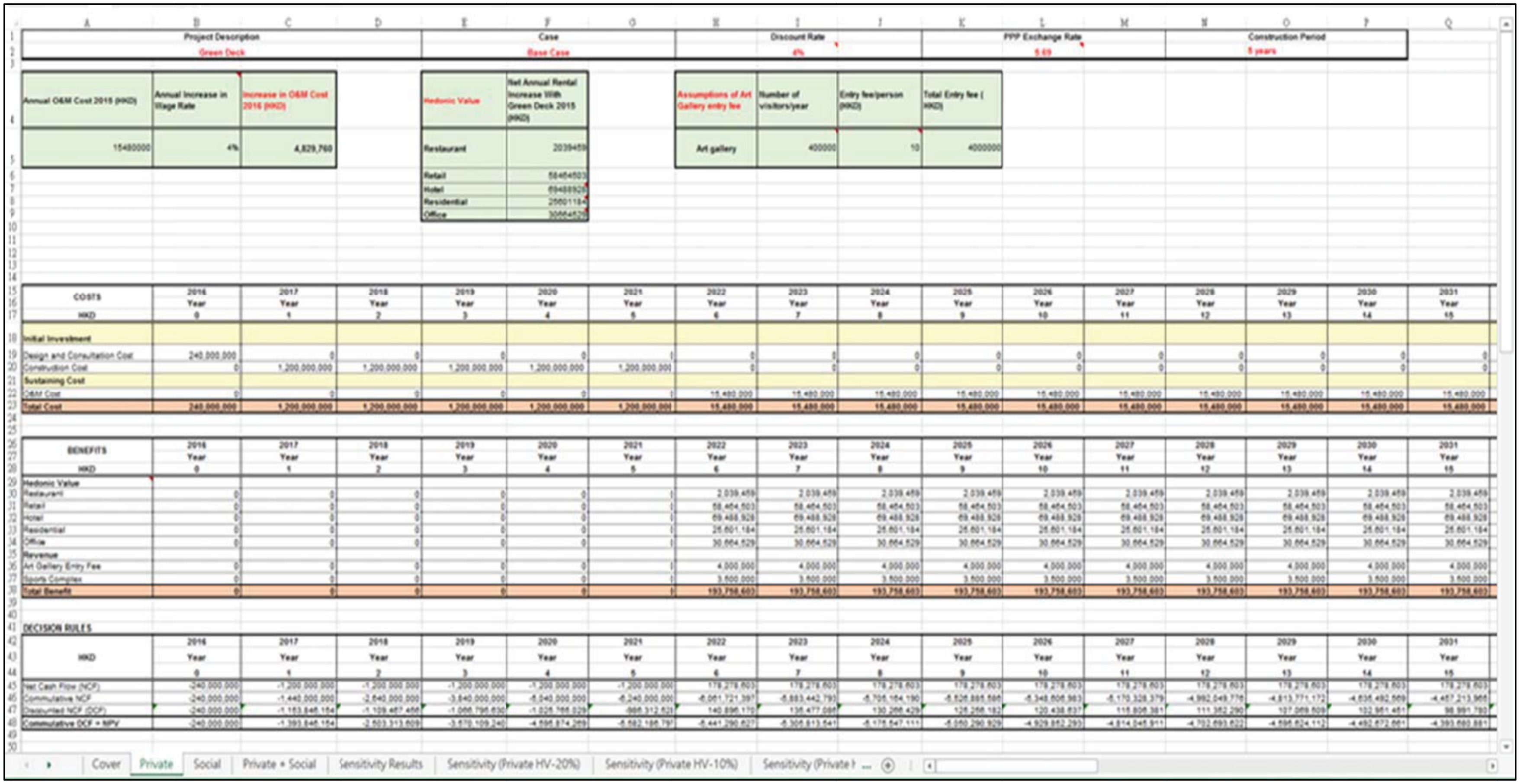
4.1 Private Costs

1) <u>Initial Investment and Design and Consultation Cost</u>

The construction cost is assumed to be HK$ 6 billion according to the consultancy report (DLN, 2014). With 5 years of construction time, the annual cost of construction will be HK$ 1.2 billion. For the design and consultation cost, it is estimated to be 4% of the construction cost, which is about HK$240 million.

2) <u>Operation and Maintenance Costs</u>

The operation and maintenance (O&M) cost of the green deck is adopted from the O&M costs of Kowloon Park per hectare (ha) per year, which is HK$3.6 million (LCSD, personal communication, September 10, 2015). With 4.3 ha, the annual O&M cost of the Green Deck will be around HK$15.5 million.



Project Description	Case	Discount Rate	PPP Exchange Rate	Construction Period
Green Deck	Base Case	4%	5.69	5 years

Annual O&M Cost 2015 (HKD)	Annual Increase in Wage Rate	Increase in O&M Cost 2016 (HKD)
15480000	4%	4,829,760

Hedonic Value	Net Annual Rental Increase With Green Deck 2015 (HKD)
Restaurant	2039459
Retail	58464503
Hotel	69488928
Residential	25601184
Office	30664529

Assumptions of Art Gallery entry fee	Number of visitors/year	Entry fee/person (HKD)	Total Entry fee (HKD)
Art gallery	400000	10	4000000

COSTS	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year
HKD	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial Investment																
Design and Consultation Cost	240,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction Cost	0	1,200,000,000	1,200,000,000	1,200,000,000	1,200,000,000	1,200,000,000	0	0	0	0	0	0	0	0	0	0
Sustaining Cost																
O&M Cost	0	0	0	0	0	0	15,480,000	15,480,000	15,480,000	15,480,000	15,480,000	15,480,000	15,480,000	15,480,000	15,480,000	15,480,000
Total Cost	240,000,000	1,200,000,000	1,200,000,000	1,200,000,000	1,200,000,000	1,200,000,000	15,480,000	15,480,000	15,480,000	15,480,000	15,480,000	15,480,000	15,480,000	15,480,000	15,480,000	15,480,000

BENEFITS	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year
HKD	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hedonic Value																
Restaurant	0	0	0	0	0	0	2,039,459	2,039,459	2,039,459	2,039,459	2,039,459	2,039,459	2,039,459	2,039,459	2,039,459	2,039,459
Retail	0	0	0	0	0	0	58,464,503	58,464,503	58,464,503	58,464,503	58,464,503	58,464,503	58,464,503	58,464,503	58,464,503	58,464,503
Hotel	0	0	0	0	0	0	69,488,928	69,488,928	69,488,928	69,488,928	69,488,928	69,488,928	69,488,928	69,488,928	69,488,928	69,488,928
Residential	0	0	0	0	0	0	25,601,184	25,601,184	25,601,184	25,601,184	25,601,184	25,601,184	25,601,184	25,601,184	25,601,184	25,601,184
Office	0	0	0	0	0	0	30,664,529	30,664,529	30,664,529	30,664,529	30,664,529	30,664,529	30,664,529	30,664,529	30,664,529	30,664,529
Revenue																
Art Gallery Entry Fee	0	0	0	0	0	0	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000
Sports Complex	0	0	0	0	0	0	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000
Total Benefit	0	0	0	0	0	0	193,758,603	193,758,603	193,758,603	193,758,603	193,758,603	193,758,603	193,758,603	193,758,603	193,758,603	193,758,603

DECISION RULES

HKD	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Net Cash Flow (NCF)	-240,000,000	-1,200,000,000	-1,200,000,000	-1,200,000,000	-1,200,000,000	-1,200,000,000	178,278,603	178,278,603	178,278,603	178,278,603	178,278,603	178,278,603	178,278,603	178,278,603	178,278,603	178,278,603
Commulative NCF	-240,000,000	-1,440,000,000	-2,640,000,000	-3,840,000,000	-5,040,000,000	-6,240,000,000	-6,061,721,397	-5,883,442,793	-5,705,164,190	-5,526,885,586	-5,348,606,983	-5,170,328,379	-4,992,049,776	-4,813,771,172	-4,635,492,569	-4,457,213,966
Discounted NCF (DCF)	-240,000,000	-1,153,846,154	-1,109,467,456	-1,066,795,630	-1,025,765,029	-986,312,528	140,896,170	135,477,086	130,266,429	125,256,182	120,438,637	115,806,381	111,352,290	107,069,509	102,951,451	98,991,780
Commulative DCF = NPV	-240,000,000	-1,393,846,154	-2,503,313,609	-3,570,109,240	-4,595,874,269	-5,582,186,797	-5,441,290,627	-5,305,813,541	-5,175,547,111	-5,050,290,929	-4,929,852,293	-4,814,045,911	-4,702,693,622	-4,595,624,112	-4,492,672,661	-4,393,680,881

Figure 4 Green Deck CBA excel spreadsheet layout

4.2 Social Costs

1) Cost of Temporary Traffic Congestion

The cost of traffic congestion due to the Green Deck construction is estimated by the time cost of the delay. A simple way to estimate travel time cost for each affected person is by using the average wage rate (CEEU, 2012). In Hong Kong, the average hourly wage rate is HK$60 (CSD, 2015c), so the time cost is assumed to be HK$60 per hour. According to McCann et al. (1999), the average traffic delay is about 10-15 minutes due to road work in the US urban areas (New Jersey and Salt Lake City). The average, which is 12.5 minutes, is taken as the traffic delay time due to the Green Deck construction. The daily average traffic flow of the Cross Harbor Tunnel (CHT) in year 2014 is 116,754 according to the data from the Transport Department of the HKSAR Government (Transport Department, 2014). Referring to the Annual Traffic Census 2014 (Transport Department, 2015), 70.4% of total vehicles in Hong Kong are private motor cars in 2014. Hence, taking this majority and assuming that on average there are 2 persons in each vehicle, and 223 working days per year (excluding Saturdays, Sundays, and public holidays), with 5 years of construction period, HK$650 million will be lost each year due to traffic congestion.

2) Construction Carbon emission

The carbon emission during Green Deck construction is estimated by averaging different building construction projects such as residential, commercial and hotel in various countries including UK, China, Singapore and Hong Kong. The average construction emission found is 415kgCO_2e/m^2 (Hong et al., 2015). In order to quantify the carbon value, the social cost of carbon estimated by the US government is adopted. It is ‘an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year’, which is US$38 per tonne in 2015 dollars (Interagency Working Group on Social Cost of Carbon, 2013). As a result, with 415kgCO_2e/m^2 emission, the Green Deck construction carbon emission will cost HK$ 771,689 per annum (converted with PPP exchange rate). Table 1 shows the detail calculation.

Table 1 Construction Carbon emission and emission cost

Total Emission during construction ($kgCO_2e/m^2$)	Green deck area (m^2)	Total Emission during construction ($kgCO_2e$/year)	Cost of carbon in 2015 (US$/ton)	Annual cost of construction emission USD$
415	43,000	3,569,000 (=415×43,000/5 years)	38	135,622 (=3659,000×38/1000)

3) Operation Carbon Emission

According to the study conducted by Yang et al. (2014), the green deck is expected to consume 5,800 kWh of electricity per day. Referring to the latest emission factor of 0.64 $kgCO_2e$/kWh from CLP Power Hong Kong Limited (CLP, 2014), approximately 1.3 million kg of CO_2 equivalent will be emitted each year due to the electricity consumption during the Green Deck's operation. The cost of carbon adopted is the same as the one used for construction carbon emission. Thus, the annual cost of operation carbon emission is found to be about HK$293,000.

4.3 Private Benefits

1) Revenue

Referring to the Green Deck development master plan, there will be an Art Gallery and a Sports Complex on the deck for public use (DLN, 2014). We assumed that the Art Gallery on the Green Deck requires an entry fee, and the sports facilities in the Sports Complex requires rental fee. The entry fee of the Art Gallery is estimated as the standard ticket price of the Hong Kong Museum of Art (HK$10 in year 2015). Suppose the number of visitors is the same as the Hong Kong Museum of Art, which is 400,000 per annum (Siu, 2015), the annual entry revenue will be HK$4 million.

The sports facilities rental income of the Kowloon Park Sports Center is used as the revenue of the Sports Complex on the Green Deck. According to the Leisure and Cultural Services Department, the value is HK$3.5 million in year 2014-15 (LCSD, personal communication, September 10, 2015). As a result, HK$7.5 million of revenue from the Art Gallery and Sports Complex will be generated annually.

2) Property (Hedonic) Value

According to Hui (2014), the rental value of the potential hotels, residential apartments and office building near the Green Deck would be in average 14.11% higher than those properties that are far away from the Green Deck. Including the potential retail stores in the mid-level and the restaurant on the viewing deck, the expected total rental value of these properties is about HK$1.3 billion. With the presence of the Green Deck, HK$186 million would be generated as the hedonic benefit.

4.4 Social Benefits

1) Visitor's Expenditure

To estimate how many visitors is coming to the Green Deck, the average number of people visiting Kowloon Park and Hong Kong Park is adopted. The information provided by the Leisure and Cultural Services Department shows that there are 2.8 million and 7.2 million of visitors per year at Hong Kong Park and Kowloon Park respectively (LCSD, personal communication, July 22, 2015). The average of 5 million people is assumed to be the annual number of visitors of Green Deck. Briceno and Schundler (2015) researched on the economic contribution of parks in Washington to the US economy and reported that by visiting local urban parks, the trip related spending is found to be US$7 per day of visit for each person. By using this amount and adjusted with the PPP exchange rate, the annual visitor's expenditure of Green Deck is amounted to HK$199 million.

2) Air Pollution Reduction

Urban green space is proven to reduce the concentration of air pollutants such as NO_2, SO_2, and PM_{10} (Peng nad Jim, 2015; Jim and Chen, 2008). To evaluate the air pollution reduction benefit brought by the Green Deck, the health cost saved due to the lowered concentration of the pollutants is taken into account. The health effect of PM_{10} is commonly used as an indicator of measuring the impact of several sources of air pollutants to avoid overestimation of pollutant-by-pollutant assessment (Sommer et al., 1999). Therefore, this study only considers the health benefit of PM_{10} reduction.

Lee (2014) conducted a survey on the amount of PM_{10} reduction by the Green Deck. According to his study, with the Green Deck, there would be 38-48% reduction in PM_{10} concentration. As the amount of ambient PM_{10} due to vehicular emission is measured at 0.058 ton per day in the Cross Harbor Tunnel area (Hung, 2015), a total of 9,160 kg of PM_{10} could be reduced per year by the Green Deck.

The health cost is adopted from a study of air pollution to the health impacts done in Hong Kong (EHS, 1998). Although the study has been conducted for more than 10 years, no similar recent studies were carried out. Thus, in light of the lack of up to date data, the study result of EHS (1998) is used with inflation adjustment. The total cost of illness of both morbidity (cardiovascular and respiratory diseases) and mortality due to $1\mu g/m^3$ change in PM_{10} was presented as HK$28,360,000. Using this value, the per capital health cost is calculated (HK$28,360,000/6,156,100 people = HK$4.6). The per capita value HK$4.6 is then adjusted to 2015 value by using the Consumer Price Index. The adjusted value becomes HK$6.2.

Chart-asa and MacDonald Gibson (2015) suggested that the influence area of traffic air pollution is about 500 m from the source. Thus, referring to Figure 5, the commercial area of Tsim Sha Tsui (TST) East, PolyU, and Block One of Royal Peninsula are the regions that are affected by the CHT traffic emission. The TST East commercial area is located in zone 57 of Figure 6. According to the data provided by Ove Arup & Partners Hong Kong Limited, the total population of zone 57 is 33,450. Since only about half of the area in zone 57 is affected by the traffic emission, therefore half of the population of zone 57 is assumed to be the population at risk, which is 16,725. Adding up the total number of staff and students at PolyU (20,933 person), and the residents at Royal Peninsula Block One (841 person), the total population within 500 m of Green Deck will be approximately 38,499. As the study conducted by PolyU estimated that PM_{10} concentration will reduce by $27.4\mu g/m^3$ in average as a result of Green Deck (Lee, 2014), so the total annual health cost saved in area within 500 m of the Green Deck is about HK$6.5 million.

Figure 5 Area affected by traffic air pollution reduction

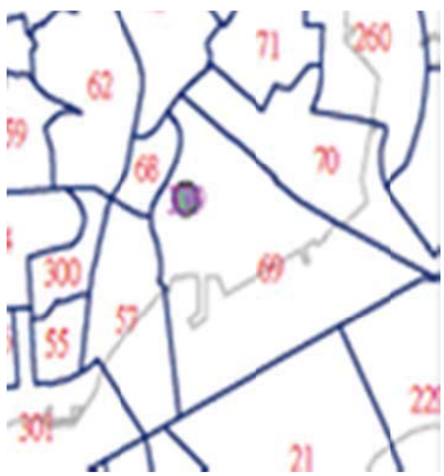


Figure 6 Population Zoning map of the Green Deck surrounding area

Source: Ove Arup & Partners Hong Kong Limited

3) <u>Carbon Sequestration</u>

Research result from a place with similar tree species and weather condition as Hong Kong is chosen as the reference for Green Deck CO_2 sequestration rate. Peng and Jim (2015) studied the average CO_2 sequestration for urban green space in Shenzhen, and found the sequestration rate to be 25.7 tonnes/ha/year. Assumed 80% of the Green Deck are green space (3.4 ha green space), by adopting the CO_2 sequestration rate in Shenzhen, Green Deck is able to absorb 87.4 tonnes of carbon every year. With the social cost of carbon mentioned earlier, around US$3,360, which is HK$19,118 (converted by PPP exchange rate) of carbon cost can be saved by the Green Deck per year.

4) Surface Runoff Reduction

In Hong Kong, the average annual rainfall is about 2,399 mm ("The Year's Weather 2014", 2015), and the rainfall at the Green Deck area is found to be 103,136 m^3 per year. According to McPherson et al. (1999), it is assumed that 40% of the annual rainfall will become runoff, therefore the annual amount of surface runoff at the Green Deck would be 41,254 m^3 (Table 2). To calculate the rainfall retention ability of the Green Deck, studies on green roof are chosen as references to estimate the percentage of runoff reduced by the plants in general. According to Berardi et al. (2014) and Speak et al. (2013), the runoff reduction ability of green roof varies from 25%-65%, with an average of 45%. Assumed Green Deck could reduce runoff by 45%, 18,564 m^3 of rain water will be absorbed per year.

Table 2 Annual rainfall in Hong Kong and annual surface runoff in the Green Deck area

Annual Rainfall in HK (mm)	Area of the GD (m^2)	Annual Rainfall in GD area (m^3)	% of rainfall becomes runoff	Annual runoff in GD area(m^3)
2,398.5	43,000	103,135.5	40%	41,254.2

The monetary value of the runoff reduction ability can be measured by the avoided cost of treating the storm water (Millward and Sabir, 2011). According to the authors, the storm water treatment cost is US1.93m^3$ in Canada. By adopting this value, and adjusted by the PPP exchange rate, the Green Deck is able to save HK$203,869 per year by reducing surface runoff.

5) Noise Pollution Reduction

Tang (2014) conducted a research on traffic noise reduction by the Green Deck, and concluded that Green Deck can reduce 3dbA of noise at the PolyU campus with mitigation measures. To quantify the benefit of noise reduction, the willingness to pay (WTP) to reduce noise per decibel per year per person is found to be US$16.9-22.6 (average US$19.775) from different studies in Europe (Howarth et al., 2001). The total number of full-time staff and students at PolyU are assumed to be the affected population (20,933 person). By using the average WTP US$19.8, the Green Deck could reduce approximately HK$7 million (adjusted by PPP exchange rate) annually by decreasing the traffic noise level.

6) Temperature reduction

The benefit of temperature reduction by the Green Deck can be divided into energy saved and greenhouse gas emission avoided.

a) Energy Saved

To measure how much energy is saved in the surrounding area by the Green Deck, the study result of Chan (2016) is adopted. To make conservative estimation, the value of Scenario 1, which is HK$2,555,993 is used. For details, please refer to Chan (2016).

b) Emission Avoided

Since the reduction in electricity consumption of the surrounding buildings is about 2.1 million kWh per year (Chan, 2016), approximately 1.4 million kgCO_2e (CLP emission factor = 0.64 kgCO_2e/kWh) can be avoided annually. As the social cost of carbon is US$38 per tonne, the total annual emission cost saved will be HK$294,750 (adjusted by PPP exchange rate).

7) Health and well-being

According to Kaczynski and Henderson (2007), if there is a park or walking trail nearby, people would increase the exercise frequency, thus improves health condition. The affected population is assumed to be the people living in the 9 constituencies near the Green Deck - Whampoa East (G16), Whampoa West

(G17), Tsim Sha Tsui East (E17), King's Park (E16), Hung Hom Bay (G18), Ka Wai (G20), Oi Man (G21), Hung Hom (G19), and Oi Chun(G22), where the total population is 158,103 (CSD, 2015b). To know the number of frequent park users, a study in Hong Kong found that among the interviewees, 40% use the park frequently (more than once a week) (Wong, 2009). For the rest of the 60% (94,862 person), with the presence of the Green Deck, it is assumed that 55% would increase the park use and become physically active (Kaczynski and Henderson, 2007).

Louie and Hui (2001) conducted a study in Hong Kong about the medical cost difference between physically active (take part in any types of sports twice or more a week, with a minimum of 20 minutes each time) and inactive person. The annual medical cost difference found is HK$1,500 (adjusted to 2015 HKD by consumer price index – medical service). Therefore, annual medical cost of HK$78,256,697 can be saved with the presence of the Green Deck.

8) <u>Travel time reduction</u>

If the Green Deck is constructed, the footbridge connecting PolyU and the Hung Hom station will be widened, and some of the pedestrians will be diverted to the upper deck as well. The total pedestrian travel time saved during the AM and PM peak hour is found to be 0.075 minutes per person (Hung, 2015; Lam et al., 2000). Assuming half of the PolyU students and full time staff use the footbridge, the total number of people affected will be 10,467. The time cost is estimated by the average wage rate in Hong Kong, which is HK$60/hour (CSD, 2015c). Thus, the annual total travel time cost saved would be about HK$287,809.

9) <u>Property (Hedonic) Value</u>

The presence of parks is found to have positive effect on the rent of nearby properties. Studies showed that the influence can be as far as 2,000 feet from the park, while most of the value will be within 500 feet (Harnik and Welle, 2009; The Trust for Public Land, 2010). However, the percentage increase in rent will gradually reduce with a decrease in distance from the park (Sherer, 2006). To make a conservative estimation, the properties within 1,000 feet from the Green

Deck are taken into account, where those located at the first 500 feet having a higher percentage increase of rent than the properties found at the rest of the 500 feet. The percentage increase in rent due to Green Deck is adopted from Hui (2014), and we assumed that the rent is 14.11% and 7.33% higher for the properties within first 500 feet and for the rest respectively. Figure 7 illustrated the area affected by the hedonic effect.

The total annual rental income for the properties within first 500 feet of the Green Deck is about HK$70 million (including a hotel and an office building). As there is 14.11% increase in rent with the Green Deck, the annual net benefit of rental increase would be approximately HK$70 million. For the properties within 1,000 feet, but beyond first 500 feet of the Green Deck, the total annual rental income is HK$815 million. With 7.33% increase in rental value, the net benefit would be HK$60 million per annum. As a result, the total annual hedonic value due to the Green Deck is amounted to be HK$130 million.

Table 3 summarized the costs and benefits associated with the Green Deck. With the identified direct and indirect costs and benefits, discounting is then carried out to find out the net present value (NPV), benefit-cost (B/C) ratio, and the internal rate of return (IRR) to determine if the Green Deck investment is acceptable. Finally, sensitivity analysis is conducted to identify which parameters or variables are critical in impacting the NPV.

Figure 7 Hedonic effect affected distance

Table 3 Summary of the costs and benefits of Green Deck development

Items			**Annual Values (million HKD)**
Costs	Private	Design and Consultation Cost	240
		Construction Cost#	1,200
		O&M Cost*	1.6
	Social	Cost of Temporary Traffic Congestion	6,500
		Construction Carbon Emission	0.7
		Operation Carbon Emission	0.3
Benefits	Private	Revenues (art gallery & sports complex)	7.5
		Property (hedonic) Value	186
	Social	Visitor Expenditures	199
		Air Pollution Reduction	6.5
		Carbon Sequestration	0.02
		Noise Pollution Reduction	7.1
		Surface Runoff Reduction	0.2
		Temperature Reduction (energy saved + emission avoided)	2.9
		Health and Well-being	78
		Travel Time Reduction	0.29
		Property (hedonic) Value	130

 # 5 years construction period.

**30% of the O&M cost will Increase 4% annually.*

5. THE COST-BENEFIT ANALYSIS RESULTS

The period of CBA is set at 56 years, including 5 years of construction (Table 4). The design and consultation is assumed to start at year zero, which is 2016. The analysis period will last until 2072, and benefits are expected to occur once the Green Deck starts operating at 2022. The discount rate is assumed to be 4% as it is the rate used for the CBA of infrastructure development by the Hong Kong government (Highways Department, 2009).

Table 4 Green Deck CBA evaluation parameters

Parameters	
Discounting period	Year 2016 – 2072 (56 years)
Green Deck construction period	Year 2017 – 2021 (5 years)
Discount rate	4%

5.1 Discounting

Since the costs and benefits occur in different points in time, it is not possible to do comparison as a dollar at present is worth more than a dollar in the future. Therefore, there is a need for discounting when compare a flow of money overtime (Campbell and Brown, 2003). In other words, the costs and benefits are converted into present value (PV) by applying a discounting factor. The PV is calculated as follow:

$$PV = \frac{C_1}{(1+r)^t} \tag{1}$$

where,

PV = present value;

C_1 = cash flow at period 1;

r = discount rate;

t = time period.

5.2 Net Present Value

The NPV is one of the decision rules to evaluate whether the investment should be accepted. It is the sum of the discounted cash flows over the period of analysis, which is calculated as:

$$NPV = \sum_{t=1}^{T} \frac{(B_t - C_t)}{(1+r)^t} \tag{2}$$

where,

T = time horizon;

t = time period;

B = discounted benefit;

C = discounted cost;

r = discount rate.

If the NPV is positive, it simply denote that the total discounted benefits exceeds the total discounted costs, which is a preferred investment option. The NPV of the Green Deck is found to be about 2.2 billion (Figure 8), therefore with this criterion, the Green Deck is deemed as an acceptable investment.

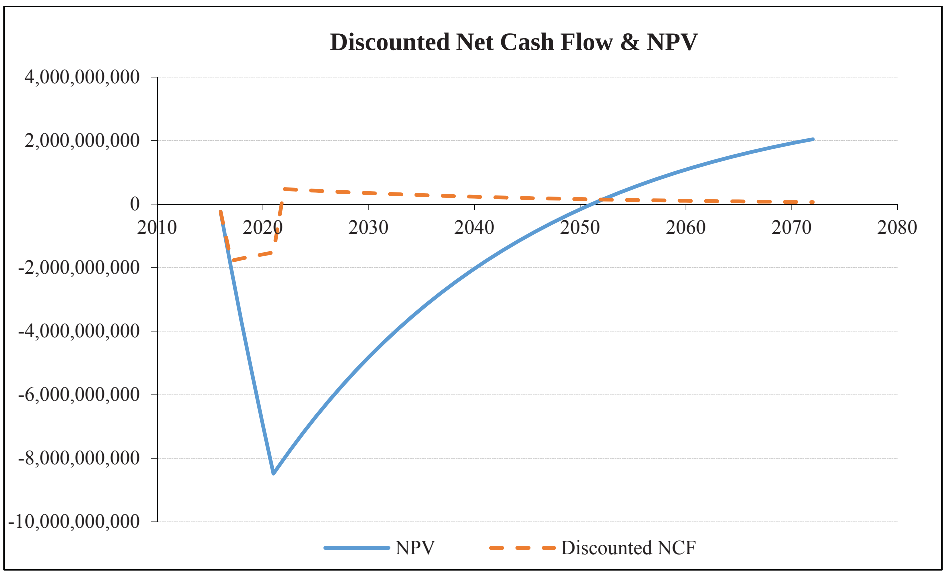


Figure 8 Discounted net cash flow and net present value of Green Deck

5.3 Benefit-Cost Ratio

The other decision rule that is usually used in CBA is the benefit-cost ratio, which is the ratio of total discounted benefits to total discounted costs. If the B/C ratio is larger than 1, the investment is regarded as acceptable as the total benefits outweigh the total costs. This is calculated by:

$$BCR = \frac{\sum_{t=1}^{T} B_t / (1+r)^t}{\sum_{t=1}^{T} C_t / (1+r)^t} \qquad (3)$$

where,

T = time horizon;

t = time period;

B = discounted benefit;

C = discounted cost;

r = discount rate.

The B/C ratio of Green Deck is 1.3 (Table 5), which shows that there are more benefits than costs for the Green Deck development.

Table 5 Green Deck benefit-cost ratio

	Value (billion HKD)
Total Discounted Benefits	11
Total Discounted Costs	8.8
Benefit-Cost Ratio	1.3

5.4 Internal Rate of Return

The IRR is the rate of return of the investment project that makes the NPV equals zero. This also means the maximum interest rate that the investment project can pay for resources use and still manage to break even (CEEU, 2012). If the IRR is larger than the discount rate, it means that the NPV is positive, which indicates that the investment project's total discounted benefits is larger than the total discounted costs. Referring to Figure 9, the IRR of the Green Deck development project is 5.3%, which is larger than the discount rate (4%). As a result, under this decision rule, the Green Deck would be an acceptable project.

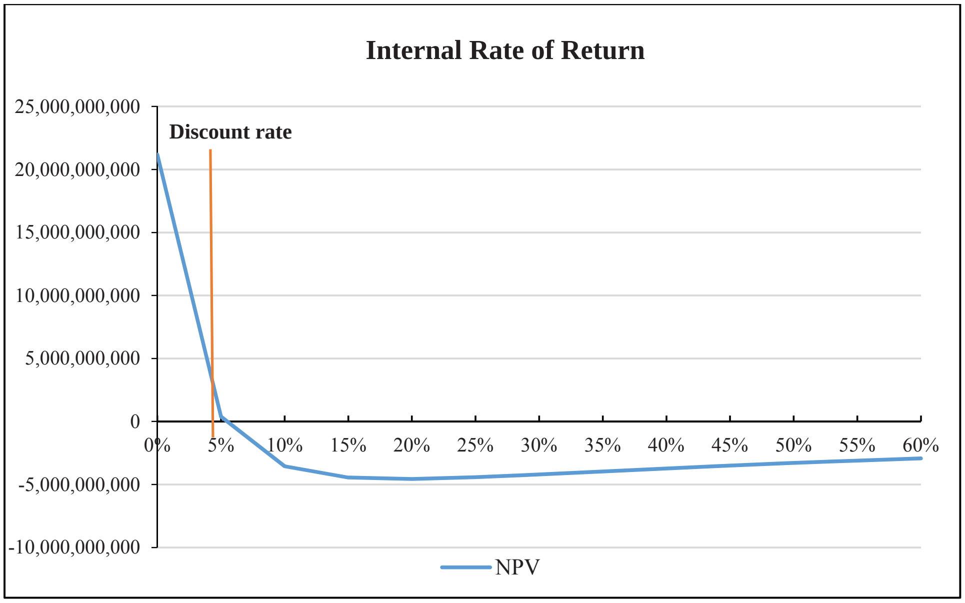


Figure 9 Internal rate of return (IRR) of Green Deck

6. SENSITIVITY ANALYSIS

Sensitivity analysis is an essential element in the CBA process. It is regarded as a risk assessment with the main purpose of determining the variables that are critical in altering the outcome of the CBA (CEEU, 2012; Florio et al., 2008). This is usually carried out by adjusting the variables by a certain amount (e.g. ±10-20%) that is significant enough to observe the changes of the NPV or IRR. In this study, four major elements are selected to test the significance on NPV – 'private hedonic value', 'social hedonic value', 'visitor's expenditure', and 'health and well-being'. The percentage increase in property values due to the Green Deck, the amount of money that visitors spend, and the percentage of population that would increase exercise frequency due to the Green Deck are adjusted for ± 10% and 20%, one element at a time to test which one is the most sensitive to the NPV.

Table 4 presents the percentage changes of NPV when the selected variables change by 10% and 20%. Visitor's expenditure shows the greatest changes among the other variables, having 16% and 32% change in NPV when the amount of expenditure change by 10% and 20% respectively. Figure 10 further demonstrates the sensitivity analysis result. The slope of the sensitivity curve of visitor's expenditure and the private hedonic value are the largest, so these two variables are relatively critical in affecting the NPV, and both are having similar significance. The health and well-being is the least critical variable among the four with the flattest sensitivity curve. A ±20% change would only result in 13% change in NPV (Table 6).

The change in visitor's expenditure are set as two different scenarios. Scenario 1 describes a decrease in visitor's expenditure for 20%, and Scenario 2 represents an increase in visitor's expenditure for 20%. Table 7 shows that for Scenario 1, the NPV would reach as low as HK$1.5 billion. While for Scenario 2, it would be as high as HK$2.9 billion. The B/C ratio ranges from 1.17 to 1.33, which are all larger than one. The IRR of Scenario 1 is the lowest, which is 4.9%, but it is still greater than the 4% discount rate.

Table 6 Percentage changes of NPV to changes in four variables

Variables	Change in NPV with 10% change in variable	Change in NPV with 20% change in variable
Visitor's spending	16%	32%
Percentage increase in rent due to Green Deck (Private Hedonic Value)	15%	30%
Percentage increase in rent due to Green Deck (Social Hedonic Value)	8%	16%
Percentage of the population that increase exercise frequency due to Green Deck (Health and Well-being)	6%	13%

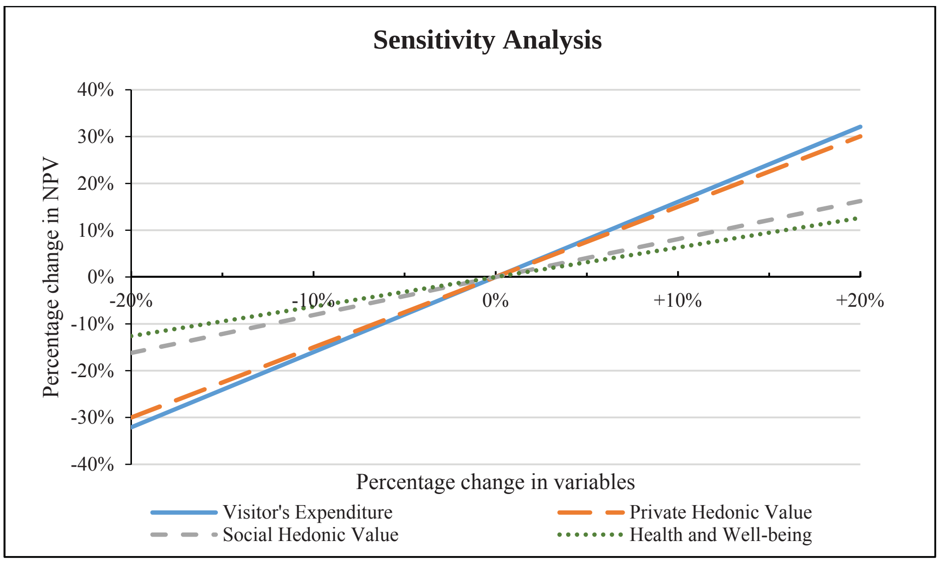


Figure 10 Sensitivity of NVP to changes in different variables

Table 7 Value of NPV, B/C ratio, and IRR of the Green Deck

	Base Case Scenario	Scenario 1	Scenario 2
Net Present Value (HK$ million)	2,226	1,519	2,934
Benefit-Cost Ratio	1.25	1.17	1.33
Internal Rate of Return	5.3%	4.9%	5.7%

7. DISCUSSION AND CONCLUSION

This study presented the CBA of the Green Deck development proposed by the PolyU, which can serve as a reference in the decision-making process. Both tangible and intangible costs and benefits are taken into account to compute the NPV, B/C ratio, and the IRR to decide whether the Green Deck project is considered as an acceptable and beneficial investment to the society. The base case scenario shows a B/C ratio that is larger than 1, a positive NPV, and an IRR that is bigger than the discount rate (Table 7). Based on these decision rules, the Green Deck project is hence considered as economically feasible. Considering different scenarios, the NPV of the Green Deck development ranges from HK$ 1.5 billion to HK$ 2.9 billion. Figure 11 shows the share of the benefits in terms of present value. It can be seen that social benefits consists of about 2/3 of the total benefits, which is greater than the private benefits. Therefore, from the society point of view, the Green Deck development could be beneficial to the public.

Referring to Figure 8, the NPV reaches zero at around year 2051, which means that the Green Deck development has a payback period of approximately 35 years. For most green infrastructures, it is not uncommon that the discounted payback period tend to extend to more than 10 years (Valderrama et al., 2013). Ding et al. (2014) suggested that the payback period could be as long as 20-30 years for infrastructure projects in Asia, and Flyvbjerg (2007) even reported a payback period of 55 years for the Copenhagen Metro construction project. Comparatively speaking, the payback period of the Green Deck development is within a reasonable range.

Sensitivity analysis is carried out to test the significance of the variables to the NPV. Four variables were chosen, and the result shows that the visitor’s expenditure and the private hedonic value are the two most significant variables that impact the NPV among the selected variables. It is not surprising that these two variables have the greatest influence to the NPV as they share the highest proportion among all the benefits in terms of present value (Figure 11). As seen in the figure, the largest benefit is from visitor’s spending, consisting of 32%, while the private hedonic value shares 30% of the total benefit, ranking as the second highest value. The social hedonic value ranks third, making up 21% of the total benefits.

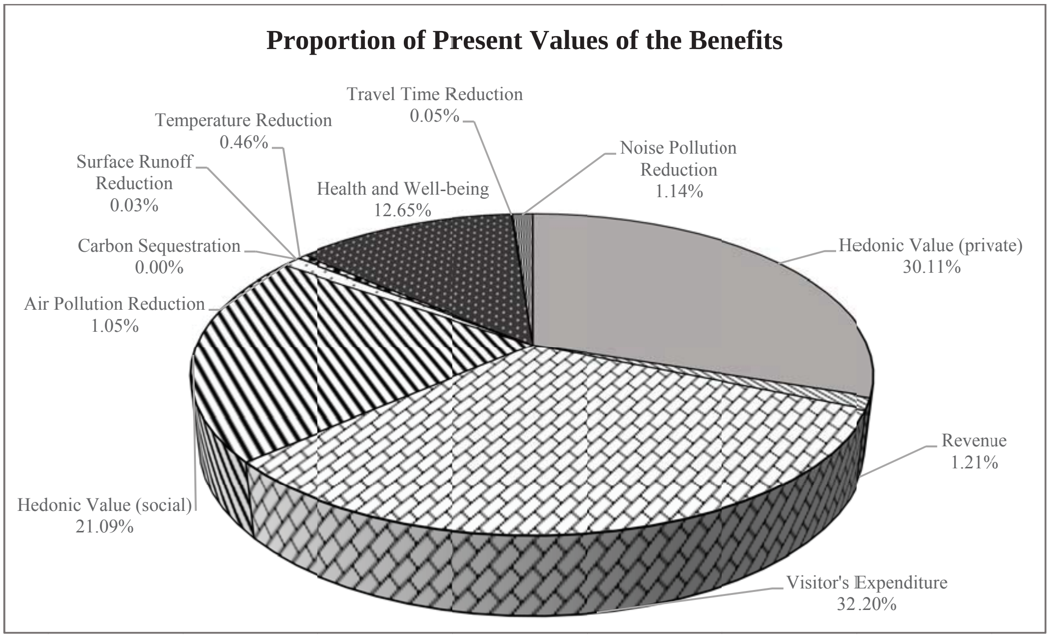


Figure 11 Share of the benefits in terms of present value

In conclusion, this study gives a preliminary and brief estimate on the costs and benefits of the Green Deck development. It is noted that due to the lack of information, there are a number of limitations including a general estimation by solely considering the average wage rate as the time cost of the road users, and a brief estimation on the number of passengers on each vehicle for calculating the cost of temporary congestion during the Green Deck construction. Also, although the Hong Kong Government suggested using 4% discount rate for infrastructure projects, there is no consensus on the choice of discount rate yet (ranging from 3-8% in different countries). Despite the limitations, this ex-ante CBA could provide a reference on whether the Green Deck development is economically feasible and at the same time serve as a tool in the decision making process.

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